PBFA I PERFORMANCE MONITORING AND EVALUATION SYSTEM (PMES)*

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Abstract

The PBFA I accelerator is a large distributed system which, in effect, contains 36 separate accelerators. Conventional analog recording of 8 to 10 monitor signals from each accelerator module is undesirable from a cost standpoint as well as from the standpoint of physically interpreting the data. It would be possible to monitor just one output signal from each module; however, in an operating environment it would be helpful to be able to pinpoint the stage within a module which caused the module to malfunction. The accumulation of sufficient data on each machine shot could also be used to form a data base which would be helpful in tracking long term trends in individual component operation. Such a tracking scheme could predict component failures before they interfere with the experimental program. Computer based systems have been developed for high energy physics experiments under the guidelines of the IEEE Std 583-1975 for CAMAC instrumentation. Commercially available CAMAC modules have been incorporated in a low cost 250 channel data acquisition system for the PBFA I accelerator which gives a readout of selected accelerator parameters such as peak voltages, peak currents, and switch firing times within minutes of an experimental shot.

Introduction

This paper describes an on-line data acquisition system for the Sandia Particle Beam Fusion Accelerator PBFA I. This particular system is a part of a total data acquisition facility which was designed to acquire nanosecond signals in a severe EMP environment caused by dI/dt and dV/dt on the order of 10^{15} amperes and volts per second.[1] Forty-four Tektronix 7912AD transient digitizers are available for diagnostics of PBFA I experiments. These digitizers are shared with two other experimental accelerators. Routine PBFA I accelerator diagnostics are provided by 250 channels of commercially available CAMAC modules which accept signals from specially designed NIM signal conditioning modules and other modules which furnish the required gating and trigger sources. Internal local processing of data from the CAMAC modules is done by a dedicated LSI-11/2 minicomputer which is linked to the main data acquisition Hewlett-Packard HP-1000 computer. All cabling is done with a combination of RG-331 foam flex cables and double shielded RG-214 cables which run from the monitors located on the accelerator through a cable splice room to the data acquisition screen room.

System Considerations

The design of a digital CAMAC system to diagnose a pulse power accelerator such as PBFA I depends on carefully selecting parameters which can be adequately represented by a single number giving the desired information.[2] Monitor points within the accelerator have been chosen to bracket individual subsystems which will tend to fail or exhibit time jitter as a unit. In addition, single monitors have been used wherever possible which will give an indication of two or more parameters using a single cable run (at a cost of $350) to minimize overall system cost. Relatively simple V-dot and B-dot monitors have been designed for this application and their locations on a single module of PBFA I are shown in Figure 1. A

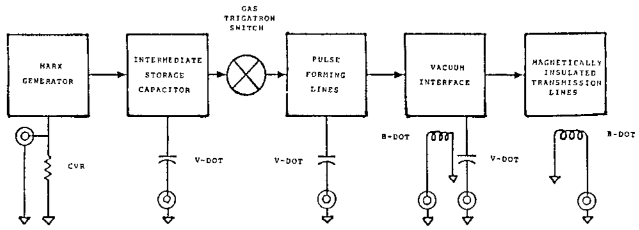

Figure 1. PBFA I module major subsystem block diagram showing location and types of PMES monitors.

prefire detection circuit has been included in PMES by adding together the signals from the Marx output voltage monitors. This signal is used to start the Marx timers. The signals from the Marx CVR's (with appropriate cable delays) are then used to stop their normal timer channels. In the event of a Marx prefire, the voltage signal from this Marx starts all Marx timers. As each Marx self fires, the CVR signal stops its respective timer channel giving increasing times for the later Marxes.

The PMES operates in a stand-alone mode with a Standard Engineering MIK-11/2 crate controller which is supported by a dual double density floppy disk system. Special NIM modules have been developed for this system to condition signal lines and to provide gate and trigger signals. Inputs to the CAMAC time digitizers are buffered by 16 channel avalanche discriminator modules. Inputs to CAMAC gated peak detectors and integrators are processed by modules which can contain combinations of attenuators, power splitters, pulse inverters, and fast integrators capable of working in a 50 ohm system. Trigger fanout modules with four TTL input channels and six NIM outputs per channel are used to start the time digitizers. Gate generator modules, containing an internal, settable delay module, with one TTL input and four NIM outputs are used to enable the peak detectors at the time of peak voltage or current. All modules use PC board assemblies to achieve a cost of $400 per system channel including computer components, software, hardware, and monitors. A typical signal channel is shown in Figure 2. PMES is presently monitoring the signal channels shown in Table I. A hardwire link is also set up to transfer data files to the main data acquisition HP-1000 computer for archiving and plotting.

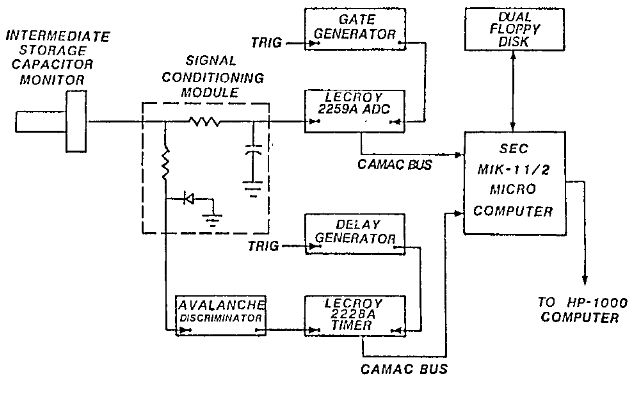

Figure 2. Typical PMES signal channel showing both peak voltage and timing digitizers on intermediate storage capacitor.

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14. ABSTRACT
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TABLE I

PMES Diagnostic Channels Presently Installed on PBFA I

MARX TRIGGER PULSER	-9 TIMERS
TRIGGER AMPLIFIERS	-2 TIMERS
MARX CURRENT	-36 TIMERS
(NORMAL/PREFIRE)	-36 PEAK DETECTORS
INTERMEDIATE STORE VOLTAGE	-36 TIMERS
	-36 PEAK DETECTORS
GAS SWITCH TRIGGER	-6 TIMERS
TRIGGER AMPLIFIERS	-2 TIMERS
LINE 1 VOLTAGE	-36 PEAK DETECTORS
VACUUM INTERFACE CURRENT	-36 TIMERS

Software

Software for the PMES is very similar to that for the HP facility computer. Many routines were taken directly from the HP system, however, some simplification and rewriting was required. Fortran callable subroutines which provide access to information on the CAMAC bus were supplied by Standard Engineering. Programs are available for automatic CAMAC module calibration, interactive hardware manipulation, automatic data acquisition, and transfer of data between the two systems. Data output is available in the form of a table which contains calibration data as well as data on machine operation. An example of this type of output is given in Table II. Data is also available in the form of a polar plot which is useful for a rapid visual understanding of accelerator performance. The firing time information for the Marx generators on an 18 line shot is shown in Figure 3. The firing time information for the gas switches on the same shot is shown in Figure 4. The late firing of Marx number 6 means that the voltage across the gas switch is lower at the time that the gas switch trigger signal arrives at the switch. This can account for the delay in the firing of this gas switch indicated in Figure 4. The amount of data available combined with the graphic display of the polar plots can give rise to a more complete understanding of overall accelerator performance. Statistical information is also included to the left of the polar plot for all valid data.

TABLE II

PMES Data Presented for an 18 Line Shot
(Shows calibration information and actual shot data from intermediate store V-dot timers on an 18 line shot.)

SIGNAL-ISVDTI , DEVICE-TI

SIG CH	DV CH	CRATE	SLOT	SUBCH	LAM	DATA	CAL SLOPE	CAL YINTC	TIME OFFSET	TIME
1	57	2	14	1	T	955	0.2434E-09	0.1850E-07	0.1000E+31	0.1000E+31
2	58	2	14	2	T	867	0.2468E-09	0.1846E-07	0.1255E-05	0.1487E-05
3	59	2	14	3	T	1851	0.2484E-09	0.1972E-07	0.1000E+31	0.1000E+31
4	60	2	14	4	T	860	0.2459E-09	0.1898E-07	0.1255E-05	0.1485E-05
5	61	2	14	5	T	1202	0.2447E-09	0.1992E-07	0.1000E+31	0.1000E+31
6	62	2	14	6	T	931	0.2441E-09	0.1975E-07	0.1255E-05	0.1502E-05
7	63	2	14	7	T	1137	0.2452E-09	0.1996E-07	0.1000E+31	0.1000E+31
8	64	2	14	8	T	872	0.2473E-09	0.1986E-07	0.1255E-05	0.1491E-05
9	65	2	15	1	T	1643	0.2496E-09	0.1358E-07	0.1000E+31	0.1000E+31
10	66	2	15	2	T	886	0.2553E-09	0.1243E-07	0.1255E-05	0.1494E-05
11	67	2	15	3	T	1531	0.2494E-09	0.1384E-07	0.1000E+31	0.1000E+31
12	68	2	15	4	T	869	0.2519E-09	0.1373E-07	0.1255E-05	0.1482E-05
13	69	2	15	5	T	1925	0.2541E-09	0.1425E-07	0.1000E+31	0.1000E+31
14	70	2	15	6	T	880	0.2509E-09	0.1440E-07	0.1255E-05	0.1490E-05
15	71	2	15	7	T	1982	0.2466E-09	0.1482E-07	0.1000E+31	0.1000E+31
16	72	2	15	8	T	892	0.2483E-09	0.1442E-07	0.1255E-05	0.1491E-05
17	73	2	16	1	T	1653	0.2426E-09	0.1915E-07	0.1000E+31	0.1000E+31
18	74	2	16	2	T	894	0.2467E-09	0.1912E-07	0.1255E-05	0.1495E-05
19	75	2	16	3	T	1591	0.2499E-09	0.1986E-07	0.1000E+31	0.1000E+31
20	76	2	16	4	T	924	0.2418E-09	0.1972E-07	0.1255E-05	0.1498E-05
21	77	2	16	5	T	1634	0.2484E-09	0.1986E-07	0.1000E+31	0.1000E+31
22	78	2	16	6	T	878	0.2474E-09	0.1928E-07	0.1255E-05	0.1491E-05
23	79	2	16	7	T	1642	0.2404E-09	0.2051E-07	0.1000E+31	0.1000E+31
24	80	2	16	8	T	847	0.2515E-09	0.1951E-07	0.1255E-05	0.1488E-05
25	81	2	17	1	T	1572	0.2486E-09	0.1922E-07	0.1000E+31	0.1000E+31
26	82	2	17	2	T	863	0.2472E-09	0.1962E-07	0.1255E-05	0.1498E-05
27	83	2	17	3	T	1601	0.2504E-09	0.1943E-07	0.1000E+31	0.1000E+31
28	84	2	17	4	T	850	0.2496E-09	0.1907E-07	0.1255E-05	0.1486E-05
29	85	2	17	5	T	1595	0.2508E-09	0.1906E-07	0.1000E+31	0.1000E+31
30	86	2	17	6	T	858	0.2491E-09	0.1958E-07	0.1255E-05	0.1488E-05
31	87	2	17	7	T	1577	0.2494E-09	0.2013E-07	0.1000E+31	0.1000E+31
32	88	2	17	8	T	850	0.2520E-09	0.1946E-07	0.1255E-05	0.1489E-05
33	89	2	18	1	T	1610	0.2486E-03	0.1805E-07	0.1000E+31	0.1000E+31
34	90	2	18	2	T	870	0.2508E-09	0.1761E-07	0.1255E-05	0.1491E-05
35	91	2	18	3	T	1098	0.2488E-09	0.1747E-07	0.1000E+31	0.1000E+31
36	92	2	18	4	T	845	0.2499E-09	0.1720E-07	0.1255E-05	0.1483E-05

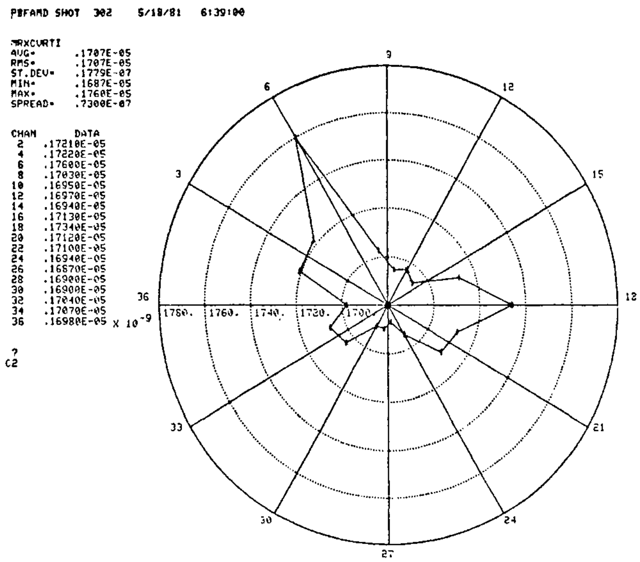

Figure 3. Typical polar plot of PMES data showing firing times of Marx generators with respect to machine time zero. Times are plotted radially with module numbers shown azimuthually (18 line shot).

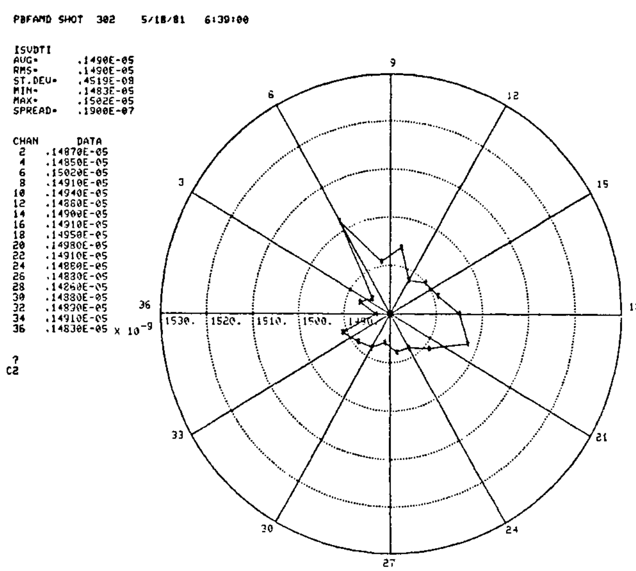

Figure 4. Polar plot of gas switch firing times for same shot as Figure 3. Notice improvement in time spread from 73 ns to 19 ns due to control trigatrons.

Conclusion

The application of commercially available CAMAC instrumentation to the diagnsotics of the 36 module PBFA I accelerator has resulted in a system with a cost of $400 per channel (not including cables) which gives a rapid indication of the performance of all subsystems within a few minutes of an experimental shot. Computer reduction of single point data from the CAMAC system combined with a polar plotting capability enables a quick verification which would be difficult to obtain with conventional recording techniques. The system has not been operational for a sufficient time to allow it to be used as a tool to predict component failures before they occur; however, this aspect of the PMES system will be evaluated in the future.

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2. D. Pellinen. S. Ashby. P. Gillis. K. Neilson, and P. Spence, Proc. of the 2nd IEEE Int'l. Pulsed Power Conf., Lubbock, TX, 410-13, June 1979.